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# Strength Prediction of SCC using ANN

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**ABSTRACT:** Among many construction materials, concrete being most acceptable material all-round the world and among all Engineers because of its excellent strength and durability characteristics. Compaction is very much essential in concrete in order to exhibit the required strength as it has to withstand the loads that are likely to act during its life span and it is a challenging task for most of the Civil Engineers. In order to overcome the problem in the construction Industry Self-Compacting concrete was developed. Self-compacting concrete (SCC) is a highly flowable type of concrete that spreads into form without the need of mechanical vibration. This reduces the compacting effort and speed up the construction process. An effort has been made to develop concrete compressive strength prediction model for SCC with the help of Artificial Neural Networks (ANNs). The data set for analysis was collected for 3, 7 and 28-day curing periods through experiments conducted in the laboratory under standard controlled conditions as mentioned in the literatures and to validate the accuracy of developed model.

**KEYWORDS:** Concrete, Self-Compacting Concrete, Compressive Strength, Artificial Neural Network.

## I. INTRODUCTION

Concrete is the most widely consumed material in the world, after water. With growing population, industrialization, and urbanization, there is corresponding growth in the demand for infrastructure. Almost all concretes rely critically on being fully compacted. Insufficient compaction dramatically lowers ultimate performance of concrete in spite of good mix design. Concrete is a composite construction material. It is mainly composed of cement (usually Portland cement), aggregate (coarse aggregate made of gravel, crushed stone and fine aggregate as sand) water and other chemical agents to get desired properties. Because of poor compactive efforts it led to the rise of Self-compacting concrete.

Self-compacting concrete (SCC) is an innovative concrete that does not requires vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same mechanical properties and durability as traditional vibrated concrete. "Self-Compacting Concrete is defined as a concrete in which it is having a passing ability, filling ability and segregation resistance along with which can flow under its own weight without any application of external energy".

ANN was inspired by understanding the structure of the biological neurons in the human brain and knowing how it works. Recently there was a wide interest by researchers of the ANN, which is approach for nonlinearly modeling, due to its ability to approximate or predict the nonlinear mapping (or linear) between the inputs and outputs of any complicated problem with an acceptable error. The approximation is done using a learning algorithm with the help of a training data set. The training data set is used in the form of pairs of training data pairs of inputs and outputs. The ANN could be used in the situations when there is information which is imprecise or not complete. The high capability of the ANN approximation makes it a suitable tool when the relationship between the inputs and outputs is not clear. The objective of the present study is to develop a ANN model for predicting the strength of SCC.

### ANN Parameters

- a. **Pearson correlation coefficient (r):** The Pearson correlation coefficient (r) is the most common way of measuring a linear correlation. It is a number between -1 and 1 that measures the strength and direction of the relationship between two variables.
- b. **Mean Absolute Percentage Error (MAPE):** The mean absolute percentage error (MAPE) is the sum of the individual absolute forecast errors, divided by the actual values for each period. It's an accuracy measure based on the relative percentage of errors. The closer the MAPE value is to zero, the better the predictions

- c. **Mean Square Error (MSE):** The mean squared error (MSE) or mean squared deviation (MSD) of an estimator measures the average of the squares of the errors—that is, the average squared difference between the estimated values and the actual value.
- d. **Root Mean Square Error (RMSE):** Measure the accuracy of the training process. Low values show model makes more accurate predictions and fits well.

## II. LITERATURE REVIEW

**Sergio Lai and Mauro Serra [1]** carried a study on Concrete strength prediction by means of neural network. They developed a model based on neurocomputing, for predicting, with sufficient approximation, the compressive strength of cement conglomerates. Mechanical properties obtained was satisfactory when compared with experimental data.

**Mahmoud Abu Yaman, Metwally Abd Elaty and Mohamed Taman [2]** carried out the prediction of ingredients for self-compacting concrete using artificial neural network. Comparative study between two methodologies which have been applied on two different data sets of SCC mixtures. Using ANNs in proportioning SCC mixes looks very promising as the R2 values obtained in this study lie between 0.63 and 1.0.

**Hong-Guang Ni and Ji-Zong Wang [3]** carried out a study to predict 28-day compressive strength of concrete by using multi-layer feed-forward neural networks (MFNNs) was proposed based on the inadequacy of present methods dealing with multiple variable and nonlinear problems. A MFNN model was built to implement the complex nonlinear relationship between the inputs (many factors that influence concrete strength) and the output (concrete strength). The neural network (NN) models give high prediction accuracy, and the research results conform to some rules of mix proportion of concrete.

**Zhenhua Duan, S.C. Kou and Chi Sun Poon [4]** conducted an experimental study to predict the compressive strength of recycled aggregate concrete. ANN model is constructed, trained and tested using 146 available sets of data obtained from 16 different published literature sources. The ANN model developed used 14 input parameters that included: the mass of water, cement, sand, natural coarse aggregate, recycled coarse aggregate used in the mix designs, water to cement ratio of concrete, fineness modulus of sand, water absorption of the aggregates, saturated surface-dried (SSD) density, maximum size, and impurity content of recycled coarse aggregate, the replacement ratio of recycled coarse aggregate by volume, and the coefficient of different concrete specimen. The ANN model, run in a Matlab platform, was used to predict the compressive strength of the recycled aggregate concrete. The results show that ANN has good potential to be used as a tool for predicting the compressive strength of recycled aggregate concrete prepared with varying types and sources of recycled aggregates.

## III. METHODOLOGY

### a. ANN Modelling

#### Single-layer feed-forward network

In this type of network, we have only two layers input layer and the output layer but the input layer does not count because no computation is performed in this layer. The output layer is formed when different weights are applied to input nodes and the cumulative effect per node is taken. After this, the neurons collectively give the output layer to compute the output signals.

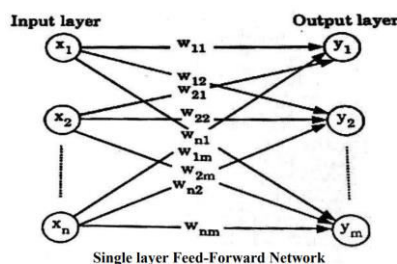


Fig.1: Single Layer Feed-Forward Network

**b. Analytical Work**

- ❖ 500 data sets are collected from peer reviewed journals
- ❖ All those data sets will be used to get the desired compressive strength (output) for known parameters such as (Cement, Fly ash, FA & CA contents and W/c ratio)

No of Data sets	Stages in ANN
400 no's	<b>Training</b> the ANN to read the input and to display the output
100 no's	<b>Testing</b> the model for correctness

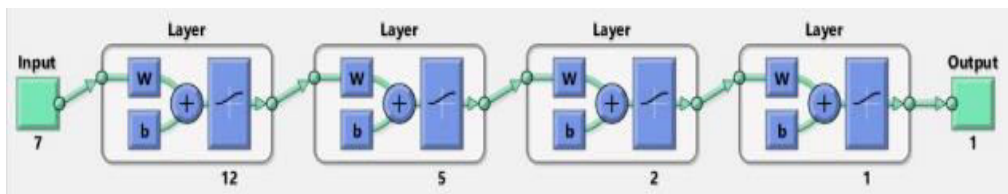
**c. Controlling Parameters for Developing ANN Model**

- ❖ Cement Content
- ❖ Fine Aggregate
- ❖ Coarse Aggregate
- ❖ Mineral Admixture
- ❖ Water
- ❖ Superplasticizer
- ❖ Age of Curing

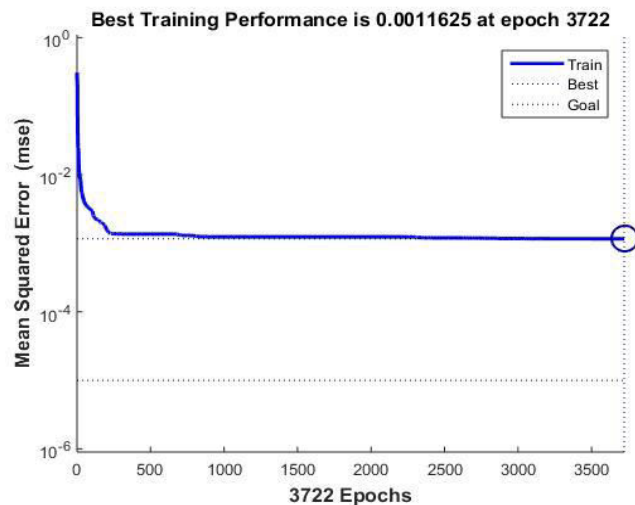
**Table.1: Input values of Data set for Developing ANN Model**

Parameters	W/B Ratio	Cement	Mineral Admx.	F.A	C.A	Superplasticizer
Min.	0.22	83	0	336	500	0
Max.	1.21	670	525	1180	1600	21.84
Average	0.44	379.08	84.62	843.99	816.42	4.26

**IV. EXPERIMENTAL RESULTS**



**Fig.2: ANN Model**



**Fig.3: MSE graph of Developed Model**

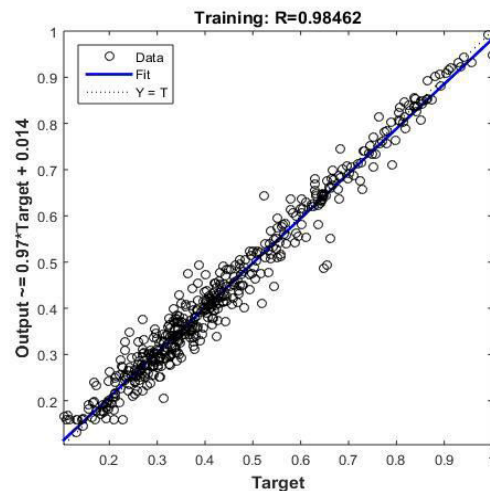


Fig.4 Person's Co-efficient graph of Developed ANN Model

Pearson's Correlation Co-efficient = 0.9846

Mean Absolute Percentage Error (MAPE) = 7.08

Mean Squared Error = 0.0011625

The obtained value of MSE for the developed ANN model is 0.0011625 is nearest to Zero as it indicates the highly accurate model. The value of Mean Absolute Percentage Error is about 7.08 which is less than 10% infers the accuracy of predicting the strength value based on input parameters. Pearson's Co-efficient value obtained for the developed model is about 0.9846 which is nearest to 1 implies that the developed model is gives the perfect relation between the input and output parameters and it shows as a best fit.

## V. CONCLUSION

1. As SCC incorporates Mineral Admixture, it reduces the carbon footprint thereby ensures green concrete and at the same time the cost of manufacturing SCC is also less which in turn reduces the overall cost of the building.
2. Pearson's correlation co-efficient value obtained for the trained data set of developed ANN model is 0.9846 which is very nearer to 1 that indicates a perfect fit
3. Means Square error of the trained data set of ANN model is 0.0011625 indicates higher precision in predicting the compressive strength values
4. As ANN estimates the strength values which is very nearer to the expected strength, it is very advantageous for the designer to make some changes in the design in order to get the desired results and to avoid the chances of failure once it is being casted.

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